Ultrasound Fracture Diagnosis in Space

Completed Technology Project (2008 - 2011)

Project Introduction

This ground-based proposal accumulated high-level clinical evidence on the sensitivity and specificity of point of care ultrasound performed by expert and novice users for the rapid diagnosis of musculoskeletal injuries. This proposal developed preliminary educational methodologies to provide just-in-time training of novice users by creating multi-media training tools and imaging procedures for non expert operators. Expanded diagnostic use of ultrasound is being substantiated for the diagnosis of specific musculoskeletal injuries deemed possible in Low Earth Orbit (LEO) and future exploration-class missions. This final report summarizes the sensitivity and specificity of non-expert performed musculoskeletal ultrasound to diagnose acute injuries. This Final Report covers Specific Aim I and II in the cooperative agreement: 1. Evaluation of the diagnostic accuracy of ultrasound for bone fractures, associated muscle trauma, and fracture healing in a ground-based study at an academic medical center. EXPERT OPERATORS: We identified patients with potential musculoskeletal injuries in an urban, Level 1 trauma center based on mechanism of injury and the presenting complaint. Potential subjects were given a summary of the study and invited to participate following informed consent. A GE Logiq-e portable ultrasound device with a 12 MHz linear probe was used for the ultrasound investigations in this study. The initial musculoskeletal (MSK) evaluations were performed and interpreted by ultrasound experts with extensive experience in MSK ultrasound. These examinations were also used to fashion cue cards and short video based educational aids to allow non-expert operators to perform complex ultrasound examinations for the later investigations in Specific Aim II. The examinations confirmed earlier investigations at our institution which have demonstrated a very high sensitivity and specificity for ultrasound when performed with a portable ultrasound machine by an expert. There were no false positive examinations in this study. There was one false negative in a non displaced, sub-capital fracture of the hip in an obese patient. This patient also had a negative X-ray and was found to have a fracture on a subsequent MRI for continued pain. There were a number of additional soft tissue ultrasound examinations in this patient subgroup which showed soft tissue edema, hematoma formation, tendon-ligament tears, and foreign bodies. The analysis of this data set obtained and interpreted by MSK ultrasound experts suggests that 2D ultrasound provides a high degree of sensitivity and specificity for the diagnosis of musculoskeletal trauma and that 3D or volumetric ultrasound is not necessary to obtain a correct diagnosis in experts' hands. NOVICE OPERATOR: Over 850 patients were screened for enrollment in the emergency room at Henry Ford Hospital. Initial patient screening was done by Trauma Surgery or Emergency Medicine staff based on mechanism of injury, history, and presenting signs and symptoms suggestive of significant musculoskeletal injury. Informed consent was obtained and a localized ultrasound examination was completed prior to radiographic evaluation by minimally trained personnel using a 10.5 MHz linear probe. The ultrasound examination was initially done on the contra lateral, non-injured side to obtain a reference image and to

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optimize visualization and focal zone. The entire length of the bone was visualized with special attention to the injured area. A positive scan consisted of identification of cortical disruption or discontinuity. Secondary hematomas and muscular injury were also recorded. Routine radiographic imaging was then completed for comparison against the ultrasound examination. Demographic, anatomic, and radiographic information was collected for correlation to the ultrasonographic findings. A diagnostic scoring sheet with patient and exam-specific data was filled out by the operator immediately following the examination. High fidelity ultrasound images/video loops were also archived for later blinded review. The sensitivity and specificity of the test was determined for the operator and the blinded reviewer. The majority (78%) of the patients entered into the study were male with an average age of 38 (range 18-84). The majority of injuries involved falls (72%), followed by motor vehicle accidents (19%) and assaults (8%). This study comprises the largest comprehensive investigation of the use of point of care ultrasound for the diagnosis of musculoskeletal injury by non-expert operators. Approximately 700 acute care examinations were performed by just-in-time operators with and average examination time of less than 10 minutes. There was no statistically significant difference in examination quality or diagnostic accuracy between expert and novice users in this trial. The overall sensitivity of ultrasound for the detection of fractures was 97% (confidence interval 0.38-0.46) and the specificity was 99% (confidence interval: 0.94-0.99) with a prevalence of 0.14. Subgroup analysis shows that the sensitivity is less for fractures in the hand and foot which is most likely related to the complexity of the examination in this area. There were a limited number of examinations of the femur, hip, and facial bones making statistical analysis impractical; however, observations of this technique suggest that it could be reliable if appropriate attention is given to technical factors including probe selection and depth in larger patients. We have also evaluated fracture healing in a limited number of patients with hand and rib injuries. Fracture callus formation is readily apparent at 3-4 weeks and the maturation of the bony healing can be followed over a more prolonged period with specific ultrasound findings.

Anticipated Benefits

A large scale analysis of our data has demonstrated that point of care ultrasound is a rapid, accurate, and reproducible test to diagnose acute injury to the musculoskeletal system. This technique can be used by non-experts to rapidly diagnose injuries to the upper and lower extremities, chest, and hands/feet to guide therapy. This technique can be expanded for use in the pre-hospital setting, in military conflicts, and in natural disasters to aid triage decisions. The intuitive Fracture Catalog developed in this proposal is currently being used to train medical students in ultrasound and is a valuable tool for military and under served locations worldwide.

Organizational Responsibility

Responsible Mission Directorate:

Space Operations Mission Directorate (SOMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Human Spaceflight Capabilities

Project Management

Program Director:

David K Baumann

Project Manager:

Sharmila D Watkins

Principal Investigator:

Scott A Dulchavsky

Co-Investigators:

Ashot E Sargsyan
Douglas R Hamilton
David Amponsah

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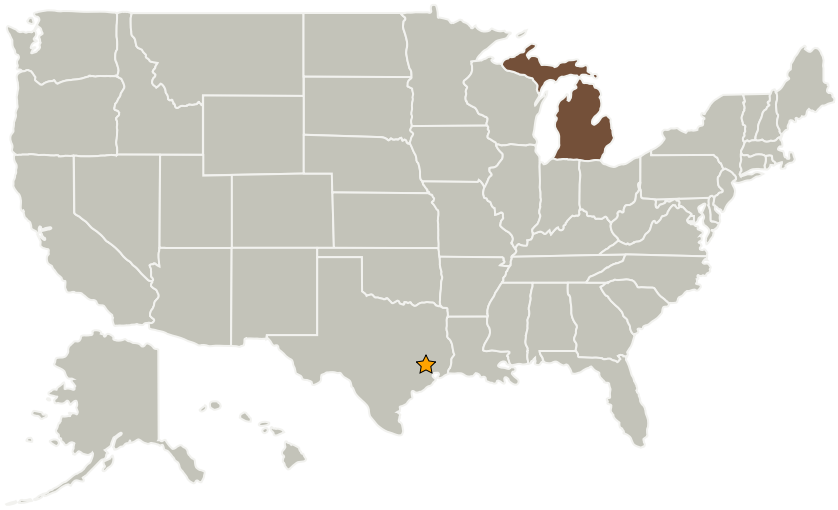
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
Henry Ford Health System	Supporting Organization	Industry	Detroit, Michigan
KBRwyle, Inc.	Supporting Organization	Industry	Houston, Texas

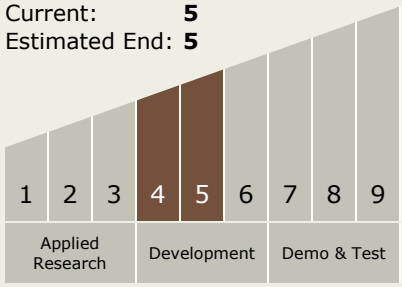
Primary U.S. Work Locations
Michigan

Project Transitions

August 2008: Project Start

Technology Maturity (TRL)

Start: **4**
Current: **5**
Estimated End: **5**



Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.3 Human Health and Performance
    - TX06.3.1 Medical Diagnosis and Prognosis

Target Destinations

The Moon, Mars

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September 2011: Closed out

Closeout Summary: This ground-based proposal accumulated high-level clinical evidence on the sensitivity and specificity of point of care ultrasound performed by expert and novice users for the rapid diagnosis of musculoskeletal injuries. This proposal developed preliminary educational methodologies to provide just-in-time training of novice users by creating multi-media training tools and imaging procedures for non expert operators. Expanded diagnostic use of ultrasound is being substantiated for the diagnosis of specific musculoskeletal injuries deemed possible in Low Earth Orbit (LEO) and future exploration-class missions. This final report summarizes the sensitivity and specificity of non-expert performed musculoskeletal ultrasound to diagnose acute injuries. This Final Report covers Specific Aim I and II in the cooperative agreement: 1. 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Stories

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/8256)

Project Website:

https://taskbook.nasaprs.com